# POLOXALENE FOR ALFALFA BLOAT PREVENTION IN BEEF STEERS--FEEDING METHODS, GROWTH EFFECTS, AND RATE OF DRUG REMOVAL FROM THE RUMEN

by

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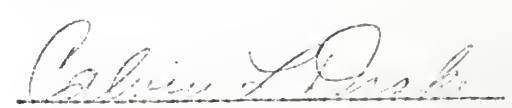

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## Introduction

The means of safely introducing legume pasture into a profitable pasture management program has been studied in the past with little success. Graber (1927) found that "the growth of sweet clover in bluegrass trebled the yields of this pasture grass." However, the danger of legume bloat in ruminants has been a strong deterrent to this type of pasture improvement.

Legume pasture containing 50% or more grass is commonly believed to be safe for ruminant animals. However, grasses become established slower than legumes and at times a legume-grass pasture can have a predominance of legumes and will become dangerous.

Clipping legume pasture helps but does not completely control bloat. Feeding legume soilage or grass-alfalfa hay, in most instances, has been successful.

The numerous management problems involved in utilizing alfalfa or other legumes as pasture have limited the adaptation of legume pasture. The culmination of decades of research has resulted in the recent discovery by Bartley (1965) of poloxalene as a preventive for legume bloat. This discovery opened a new area of research and study. Because of the bloat problems, very little information is available concerning the value of alfalfa pasture for beef cattle, a feed source which could prove valuable for pasturing beef cows and summering and fattening steers.

This project was designed to study the problems involved when grazing steers on summer pasture with and without supplemental grain and a source of poloxalene. The research involved the following: (1) a

comparison of the rate of gain of steers fed rolled sorghum grain on alfalfa pasture to that of steers fed the same grain ration and free-choice alfalfa hay in drylot; (2) a comparison of the effectiveness of Bloat Guard[1] in the grain ration and poloxalene in molasses salt blocks; (3) a study of the rate of removal of poloxalene from the rumens of beef steers fed different quantities of fresh alfalfa. The primary purpose of the latter study was to determine if the consumption of large quantities of alfalfa would dilute and impair the effectiveness of poloxalene.

Several studies have been conducted to investigate the effectiveness of Bloat Guard in self-fed rations. Intake under this regime appears to be uniform enough for continued control. In a pilot project by Drake (1967) poloxalene was found to effectively control bloat when fed with the grain ration or supplied in a molasses salt block to steers grazing lush alfalfa pasture. This pilot study gave an indication as to the proper stocking rates for alfalfa pasture.

Wise et al., (1965) showed that steers fed low levels of concentrates on ladino clover gained more than 2 lb. daily. The concentrate intake was limited to less than 8 lb. per day by including 7% to 10% salt in the ration. A 0.43 lb. increase in gain occurred in animals implanted with Stilbestrol.

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[1]Tradename of Smith Kline and French Laboratories, product containing 53% poloxalene.

# Review of Literature

## Cost of Bloat

Losses from frothy bloat are quite difficult to measure. The most important factors causing loss are reduced weight gains, reduced milk production, inability to use the most productive feeds, increased labor and management costs, and death losses. Since bloat is quite unpredictable, it would take extremely large numbers of animals to provide a realistic measurement of loss in weight gain and milk production. The loss in milk production is difficult to evaluate and probably could never be accurately quantitated. Decreased use of pasture is also difficult to evaluate with present research information. Additional manpower is required for general supervision and to provide proper pasture rotation. Death is a measurable item as is labor and expense for materials used in the treatment of bloat.

Numerous figures have been quoted for the bloat losses incurred by the livestock industry. Lindahl et al., (1957a) quoted the value of $40,000,000 annually from animal deaths due to bloat. The USDA (ARS, 1965) estimated that over $100,000,000 annually were lost due to bloat. Of this, beef losses accounted for $56,712,000 and dairy for $7,193,000. Milk losses were estimated at $41,035,000. These figures did not include losses due to poor utilization of superior pastures.

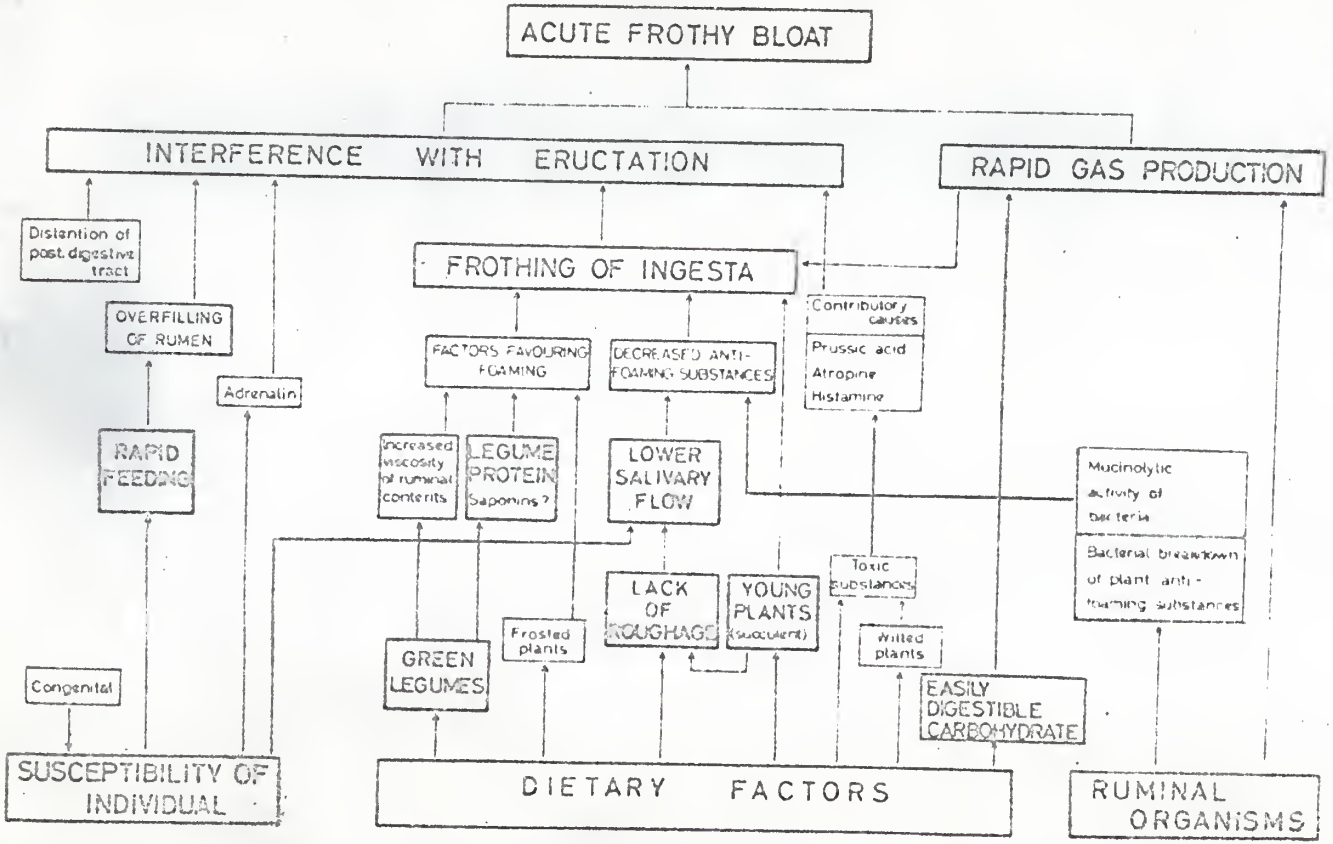
## Etiology of Legume Bloat

Clinically, bloat is characterized by a marked bulging of the left flank, a weak rapid pulse, respiratory distress, groaning and staggering, straining, salivating, protrusion of the anus, vomiting, bluing

of exposed membranes due to lack of oxygen, and finally, if not relieved, death due to asphyxiation probably caused by pressure on the thoracic cavity (Bartley, 1967). Gas normally formed in the forestomach of ruminants is expelled primarily by eructation through the esophagus. Only when gas formation exceeds gas elimination does bloat occur.

Legume bloat is classified as acute, frothy bloat, and is distinguished from (1) free gas bloat, which is due to obstruction which physically interferes with expulsion of fermentation gases, and (2) chronic bloat, which is persistent and occurs intermittently as a symptom of some other disorder. Frothy bloat is a complex of numerous factors. Grosskopf (1964) points out the complexity and interaction of the various factors influencing the occurrence of bloat. (Figure 1).

Figure 1. Factors responsible for the development of acute frothy bloat.[1]




[1] Taken from Grosskopf (1964)

Although cattle, especially lactating dairy cows, appear to be the main species affected, bloat is not confined to this species alone. Bloat is also common in sheep on green legumes and has been observed in numerous wild animals.

Bloat may be a heritable factor, as shown by the marked similarity in incidence of bloat between identical twins (Johns, 1958). Mendell and Boda (1960) observed that non-bloaters secrete greater quantities of saliva than do bloaters. This may present a logical explanation for inherited differences in bloat susceptibility, since bloaters may differ in rate, amount, and compositions of salivary secretion.

Gas is normally formed during fermentation in the rumen and as the rate of fermentation increases the production of gas is increased. Some feeds produce more gas per unit of time than others. According to a review on bloat by Grosskopf (1964), alfalfa hay fermentation produces approximately three times the volume of gas as an equivalent amount of sudan grass, oat hay, or grass hay. This large volume of gas must be removed primarily by eructation. Reiss (1953) described the eructation mechanism in detail. He also proved that the reflex was stimulated mainly by increased gas pressure in the rumen. This disproved the theory that coarse material in the rumen provides the stimulus for eructation. Dougherty et al., (1958) further investigated the innervation of the reflex and found a small area around the cardiac orifice particularly sensitive to gas pressure which is probably the origin of the nerve impulses governing eructation.

The eructation movement of the rumen proceeds in wavelike motions from the caudal dorsal blind sac forward to the dorsal wall of the rumen

toward the cardia (Weiss, 1953). Eructation movements usually occur following every second or third mixing movement, but in many cases when pressures become high, eructations may even outnumber the mixing movements. After the wave-like movement, the reticulum contracts twice in succession to free itself from digesta and then relaxes to clear the cardia. This allows gases to escape without a loss of digesta. The eructation reflex also serves to open the cardiac orifice.

It is generally accepted that bloat is the result of a failure of the eructation reflex to expel gas through the esophagus, due either to disturbances in the reflex itself or obstruction (Colvin et al., 1958; Weiss, 1953). In legume bloat the obstruction that inhibits the eructation of gases is the encasement of the gases in a frothy foam. Dougherty (1958) has shown the reflex action of the cervical esophageal sphincter to be inhibited by the presence of foam or fluids, but not by gas alone. These inhibitory receptors were found in a small area around the cardia. This finding, along with the encasement of the gases within the foam, suggests that it would be impossible or at best difficult for a ruminant to eructate freely during bloat.

The foam in legume bloat is a highly stable froth from which little gas is able to escape. The foam was described by Head (1959) as being mainly carbohydrate in nature. The principle constituents were sugars normally found in the pectin and hemicellulose fractions of plants. According to Head (1959), "This observation suggested that the foaming constituent appeared in solution in the rumen liquor after the plant had been physically broken down and that it later disappeared, probably by the degrading action of microorganisms." Cole and Boda (1960)

disagreed on what chemical substances caused foaming. Plant proteins, saponins, and pectin substances appeared to be involved. They also felt that the slime produced by bacteria might possibly be another factor in the frothing of digesta. Minerals might also play a role in the production of bloat. Adequate mineral supplementation is necessary for abundant and rapid plant growth. Some of the polyvalent minerals have definite effects of colloidal behavior and may stabilize foam (Cole and Boda, 1960). Bartley and Bassette (1961), using Head's (1959) method of isolating the foaming constituents, found the foam to be proteinaceous, a contradiction of Head's work. Recent Iowa work (Synhorst et al., 1963) has revealed a relationship between foaming potential and soluble protein content of the plant. These workers found that alfalfa extracts gave maximum foam stability and maximum soluble protein content during pre-bloom growth, whereas bird's foot trefoil was relatively low in soluble protein. MacArthur and Miltimore (1964, 1965) isolated and identified foam protein "18S" as the cause of legume bloat. The 18S protein was found to be a major component of plant protein and an enzyme involved in carbon dioxide fixation in the photosynthetic cycle. This indicated that it would be found in all plants. MacArthur stated that it is doubtful that 18S protein would cause bloat by itself, as many other factors must occur coincidently.

Kendall (1965) found that the optimum pH for foam formation for clovers and alfalfa was 5.5 and that maximum foaming of trefoil and lespedeza occurred at pH 7.0. This may explain why some plants may not exhibit high foaming qualities, even though all plants contain the 18S protein.

Pectins and saponins are also thought to be contributors to stability of foam in legume bloat. The saponins by themselves will produce extremely stable foams *in vitro* (Lindahl *et al.*, 1957b). However, most researchers now agree that saponins by themselves will not produce a stable foam, as the proper conditions to form a stable saponin foam do not exist in the rumen (Barrentine, 1960; Cole and Boda, 1960). They may, however, play a role in stabilizing the foam. Plant pectins and particulate matter may act as foam stabilizers once foams are formed. Lipids and tannins, however, are naturally-occurring bloat preventives in plants. Workers have succeeded in partially controlling bloat with tannins and lipids (Cole and Boda, 1960; Mangan *et al.*, 1959). Lipids and tannins increase as plants mature; at the same time, bloat danger decreases. In general, factors that increase with plant maturity inhibit bloat and factors that are highest in the immature plant are conducive to bloat.

As previously stated, saliva volume and/or composition may be an important inherited factor which can cause differences in bloat susceptibility. Saliva contains antifoaming agents, since Van Horn and Bartley (1961) observed that the addition of saliva to foaming rumen contents increased the rate of release of trapped gas. Mucilage from linseed oil meal also increased the rate of gas release. This brought forth the postulation that reduced salivation during consumption of lush forage containing foam-provoking constituents might be a factor in bloat etiology. Mucin actually appears to be the constituent which breaks and/or prevents foaming. Bartley and Yadava (1961) established that animal mucins introduced into the rumen of cattle grazing alfalfa prevent bloat for as long

as four hours.

Several workers have shown that fiberous feeds, such as hay, may stimulate four to five times as much salivary flow per unit weight of feed consumed as do nonfiberous feeds (Balch, 1958; Bailey, 1959; Meyer et al., 1964). Mendel and Boda (1960) found that young succulent legumes will stimulate less salivary secretion than more mature legumes or hay. This also points out why damp or wet legumes are highly bloat-provoking. Reduced salivary flow will not induce bloat unless the digesta contains a quantity of foam forming proteins. The importance of the digesta is pointed out when bloat does not occur in animals grazing young succulent grasses.

There is ample evidence (Clark, 1965; Kodras, 1965; Fina et al., 1961) that rumen microflora are in some way related to bloat. That certain antibiotics can control bloat for a short period indicates a possible bacterial role (Johns, 1958; Mangan et al., 1959). Earlier it was shown that bacterial slimes may add to the stability of the foam produced. Clark (1965) and Kodras (1965) found that the number of protozoa increased with the approach of bloat and that a greater number burst, producing a highly viscous rumen fluid. They also found a positive correlation between bloat and protozoa numbers.

Kansas workers (Fina et al., 1961) have shown that there are rumen bacteria capable of degrading salivary mucin and that these bacteria are more prevalent in bloaters than in non-bloaters. They isolated five mucinolytic organisms which, when introduced into animals on bloat-provoking rations, caused a marked increase in bloat. Antibiotics, thus, may aid in the control of bloat by (1) destroying

mucinolytic organisms, and (2) by decreasing bacterial gas production. Consequently, bloat must be due to an imbalance between the numerous foaming and antifoaming factors.

Bloat Prevention

An ancient Roman author in A. D. 60 reported his treatment of bloat as pouring sour vinegar through the left nostril and putting two ounces of grease in the jaws (Anonymous, 1958). This was just the start of a multitude of methods that through the years have been used to treat bloat. Since saliva is apparently the ruminant's natural antifoaming remedy, bloat prevention should be directed toward the maintenance of sufficient salivary flow. Coarse palatable hay should, therefore, be available to cows continuously grazing legume pastures. However, when cows are allowed to graze legume pasture for only short periods, they will probably not consume sufficient hay. In such cases the hay should be fed before taking them to pasture. Because of the danger of overfilling, cows grazing alfalfa pasture for short periods should not be allowed to drink water prior to or for one-half hour after the grazing period (Grosskopf, 1964).

In many cases, it is not advisable or possible to remove cows from legume pasture. Antibiotics have been used to control bloat (Barrentine et al., 1956). Among the earliest antibiotics used was procaine penicillin, usually at levels of approximately 50 mg. per day. This controlled bloat from three to five days (Johns, 1958; Mangan et al., 1959), after which the microorganisms seemed to adapt, and penicillin was no longer effective. Other antibiotics have been used singly,

sequentially, and in combination to control legume bloat. Their effectiveness has also been limited to only relatively short periods. Foote et al., (1965a) felt that antibiotic effectiveness might have been limited by inactivation by penicillase and/or acid hydrolysis. Therefore, he used resistopen, a semi-synthetic penicillin which is resistant to both. In his trials bloat was effectively controlled in steers treated with 250 mg. in a gelatin capsule every other day for four periods of seven days each.

Primary interest has been in the use of surface active agents to control bloat. Reid (1959) reported successful control of bloat by spraying strips of pasture with oil. However, this method is not practical in most countries because of high labor costs. Vegetable turpentine has been used empirically for almost 150 years in treatment of acute bloat. It was shown only recently that its action was due to decreased surface tension. Several antifoaming agents, including silicones, detergents, vegetable oils, animal fats, animals mucins, and liquid paraffins have been used with some success. Various other surface active agents are available, most of which are not completely effective. Any thin oil or other substance which will lower the surface tension of the foam can be used against bloat.

Poloxalene--A Polyoxypropylene Prelyoxyethylene Block Polymer

Workers at Kansas State University (Bartley, 1965) established criteria to be met by bloat preventives. According to these criteria the compound: (a) must act rapidly (within 10 min.); (b) must be palatable; (c) must not deleteriously affect health, reproduction, rumen function,

feed intake, or quality or quantity of milk; (d) must not be eliminated in milk; (e) must not be found in body tissues five days after administration; and (f) must be economical. Furthermore, one administration must effectively prevent bloat at least twelve hours and meet physical properties such as solubility, wetting ability and dispersibility to insure maximum efficacy as a bloat preventive agent. Poloxalene was synthesized to meet these criteria. Early work showed that 10 gm. of poloxalene effectively controlled bloat for twelve hours. Five grams controlled bloat, but the control was marginal and had no carry-over effect (Bartley, 1965). Poloxalene was found by Helmer et al., (1965) to have no deleterious effect on feed intake, health, reproduction, or milk production. Leaf and Leonard (1965) tested poloxalene for its toxicological properties. Albino rats were fed 40, 200, and 500 mg. per kg. of body weight. Five hundred mg. were fed to determine if reduced consumption was due to toxic manifestations or reduced palatability. No toxicological or other undesirable effects occurred at either 200 or 500 mg. per kg. levels. Meyer et al., (1965) found that $C^{14}$ labeled poloxalene was not eliminated in milk secreted from a few hours to ten days following administration and that no residues remained in body tissues ten days after its administration. Reddy et al. (1967) found poloxalene reduced surface tension and pH of rumen fluid in fistulated cows, and had no apparent effect on milk flavor. A single dose (0.044 gm./kg. body weight) of poloxalene effectively reduced surface tension for 24 to 36 hr. and to some extent up to 48 hr. Time of sampling also appeared to cause surface tension fluctuation. Lippke and Jacobson (1965) studied the effect of poloxalene on rumen fluid and

feed intake of cattle and found that poloxalene reduced fresh rumen fluid surface tension and average of 6.7 dynes.[1] It was observed that poloxalene slightly increased gas evolution and organ motility. Maximum ingesta volume decreased as much as 16%, due to diminished foam. There was no effect on feed intake.

Bartley et al. (1965) reported three farm trials which tested the efficacy of poloxalene. In four herds in Kansas during the spring of 1964 nearly 100% control was achieved. Two herds of Holsteins received 1 gm. poloxalene per 454 gm. grain ration; another Holstein herd was fed 10 gm. poloxalene twice daily; and the fourth herd (Jerseys) received 5 gm. twice daily. The few cases of bloat occurred in one herd only (Holsteins) and each cow that bloated received less than 2.5 gm. poloxalene per feeding. Control was achieved in the fourth herd by increasing the level of poloxalene administration. In a later trial 100% control was achieved when cows consumed sufficient poloxalene (10 gm. per 500 kg. body weight per feeding). An experiment on dairy steers in Iowa also proved successful when steers consumed at least half the 10 gm. poloxalene offered. Since that time numerous trials have been held over a wide area with comparable success.

The optimum level of poloxalene administration varies with (1) the size of animal; (2) the type of legume roughage fed; (3) the quantity of hay and/or grain fed daily; and (4) the frequency of administration. Normally, 10 gm. per head per feeding is recommended.

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[1]A metric unit of surface tension. The force necessary to move 1 gm. 1 cm. per second.

Numerous methods of administering poloxalene have been used, such as (1) top dressing of the concentrate; (2) mixing in the concentrate; (3) incorporating in pellets top dressed on or mixed with the concentrate and incorporating in molasses-type blocks. Each method has certain advantages. Always important is that the animals consume sufficient poloxalene.

Foote (1965b) found poloxalene in concentrate pellets and molasses blocks to be effective in control of bloat. Steers in Foote's trial consumed 1.52 lb. per day of the block without poloxalene and 0.9 lb. per day of the poloxalene-containing blocks (6.7% poloxalene). No reason was given to justify this difference.

Molasses Blocks

Molasses-type blocks offer considerable versatility, particularly in cases where animals would not normally receive concentrates. Protein blocks have been considered, but were not deemed practical as the legume pastures are generally adequate in protein. Mineral and salt blocks have no value because of the physical characteristics and quantity of poloxalene needed.

Twenty percent salt is normally added to the molasses block to regulate consumption (Bartley, 1967). The blocks provide the only source of salt available; this increases block intake. Essig et al. (1965b) found that poloxalene had no detrimental effect on the consumption of the molasses blocks and that the animals would consume about 0.5 to 1.0 lb. of block per day. Essig tested blocks containing poloxalene at levels of 10 and 30 gm. per pound. He found that cattle having access to blocks containing 30 gm. poloxalene per pound consumed

more of the block. An average daily consumption of 13.93 gm. poloxalene reduced bloat severity and incidence. Although 49.69 gm. was more efficient, it did not completely prevent bloat. Bloat appeared to be more severe in the afternoon. Essig concluded that the block containing 30 gm. of poloxalene per pound was an effective method of reducing the severity of bloat.

Surface Tension of Rumen Fluid

The determination of surface tension is a critical process and accuracy is dependent on the technique of the individual. Proper techniques for securing rumen fluid samples for surface tension determinations have been outlined by Blake et al. (1957).

Surface tension does not appear to be influenced by the method by which the rumen sample is obtained (Blake et al. , (1957); however, the samples should be taken by the same method and at the same location in the rumen. The rumen digesta can either be allowed to stratify before straining, or the entire sample can be strained through four layers of cheese cloth to remove particles.

Changes in temperature will cause large changes in the surface tension so samples must be kept at a fairly constant temperature. Samples can be stored for short periods with little change. However, for utmost accuracy, the time after sampling should be constant. Blake (1957) showed less than 2 d. change over a 15 hr. period in a large number of samples. Under refrigeration, samples can be stored for much longer periods.

Surface tension is influenced by the time of sampling; therefore,

rumen samples should be collected at the same time each day and the same time after feeding. When foam is encountered in rumen digesta, it should not be removed, as Blake et al. (1957) has shown this to lower surface tension by as much as 4 d. He further observed that sample dilution with water does not have a significant effect on the reading. Bartley (1967) found that water does, indeed, alter surface tension, and suggested restriction of water consumption for at least 1 hr. before sampling.

## Procedure

### Grazing Trial

Following a two week adjustment period thirty-eight, 600 lb. Hereford steers were weighed, implanted with 12 mg. stilbestrol, ear tagged, marked with a black dye for easy identification, and placed in treatment groups. The treatments are shown in Table 1.

Table 1. TREATMENT DESCRIPTION

| Treatment number | Lot number | Treatment[1] |
|---|---|---|
| 1 | 1 | Six steers served as a control for lots 5 and 6. Steers were allowed free access to a self feeder filled with coarsely rolled milo grain. Feed intake was regulated between 6 and 8 lb. daily per steer by adding salt as required. No Bloat Guard was added to the grain. |
| 2 | 5 & 6 | Each lot consisted of six steers treated as lot 1, except Bloat Guard[2] was incorporated in the grain ration. |
| 3 | 2 | Four steers served as a control for lots 3 and 4. No grain or poloxalene was provided. |
| 4 | 3 & 4 | Each lot consisted of four steers each having access to molasses salt blocks containing poloxalene. Grain was not fed. |
| 5 | 7 | Four steers were placed in dry lot and fed alfalfa hay free choice. The steers were allowed free access to a self feeder filled with coarsely rolled milo grain. Feed intake was regulated between 6 and 8 lb. daily per steer by adding salt as required. |
| 6 | 8 | Four steers were treated as treatment 5, except Bloat Guard[2] was incorporated in the grain ration. |

[1]All steers in lot 1 through 6 were maintained on alfalfa pasture at all times.

[2]The starting level of Bloat Guard was 1.33 lb. per 100 lb. of grain. This was reduced as grain consumption was assured at the 6 lb. level to provide 20 gm. daily per head.

The self feeders were filled with sufficient grain to last a week. At the end of each week the remaining feed was weighed and adjustments in the percentage salt were made as required.

All steers were weighed at 28-day intervals, at the same time of day, and with a minimum of handling.

All steers were grazed in two-acre pastures. Each group, with

the exception of lots 3 and 4, received molasses blocks without poloxalene.

The degree of bloat was checked twice daily at 8 a.m. and 5 p.m. and scored as shown in Table 2.

Table 2. DESCRIPTION OF SCALE USED IN ASSIGNING BLOAT SCORES (JOHNSON ET AL., 1958).

| Score | Description |
|---|---|
| 0 | No bloat - No distention in left paralumbar fossa. |
| 1 | Slight - Slight distention in left paralumbar fossa; "puffy." |
| 2 | Mild - Marked distention in left paralumbar fossa; well rounded out between hip and rib on left side; little or no distention on right side. |
| 3 | Moderate - Well rounded out on left side, drumlike; full on right side; restless. |
| 4 | Severe - Both sides badly distended; left hip nearly hidden; skin tight; defecation; urination; incoordination; protruding anus; mild respiratory distress. |
| 5 | Terminal - Extreme abdominal distention; severe respiratory distress; cyanosis; prostration; death unless treated. |

Rate of Removal Study

This trial was conducted to determine if varying alfalfa consumption would affect the concentration of poloxalene in the rumen. It seemed possible that poloxalene would be removed faster when rate of rumen removal was increased by high alfalfa intake.

Two sets of rumen-fistulated identical twins were fed varying quantities of alfalfa with two levels of poloxalene (10 and 20 gm. daily). The experimental design is shown in Table 3.

Table 3. EXPERIMENTAL DESIGN; RATE OF REMOVAL STUDY

| Days | Alfalfa (green chop) fed/day | Twin pair $A_1$ | Twin pair $A_2$ | Twin pair $B_1$ | Twin pair $B_2$ |
|---|---|---|---|---|---|
| | lb. | Poloxalene dosage (gm.) | | | |
| 1-4 | 20 | 0 | 0 | 0 | 0 |
| 5-7 | 20 | 10 | 20 | 10 | 20 |
| 8-11 | 40 | 0 | 0 | 0 | 0 |
| 12-14 | 40 | 10 | 20 | 10 | 20 |
| 15-18 | 50[1] | 0 | 0 | 0 | 0 |
| 19-21 | 50[1] | 10 | 20 | 10 | 20 |
| | Replication of above trial | | | | |

[1]Maximum capacity.

Poloxalene was administered daily in a gelatin capsule placed in the rumen through the fistula. Poloxalene feeding periods were 3 days in duration with a 4 day transition period as shown in Table 3. Samples of rumen fluid were taken prior to feeding and administration of poloxalene (7:00 a.m.) and 3 hr. and 12 hr. postadministration. Fresh alfalfa green chop was fed twice daily at approximately 12 hr. intervals.

Two different sampling methods were used: sampling through a strainer tube that was suspended in the rumen and sampling by removing a portion of the total contents through the fistula opening. Samples were then taken to the laboratory for surface tension determination. Some samples were refrigerated for short periods of time (less than 15 hr.). Blake et al. (1957) noted that surface tension remains relatively constant, especially when samples are kept under refrigeration.

Surface tension was determined by using a Cenco-duNouy interfacial tensiometer. The duNouy tensiometer measures the force between

two bodies by pulling a ring of a known area from the surface of one body (rumen fluid) into another body (air). The force is measured in dynes per centimeter.

The relationship between the scale units and dynes is logarithmic. This is because the arm is lifted by twisting a wire and the more torque on the wire the greater the force needed to move the arm one increment. Since readings vary between operators, each individual must develop his own calibration curve. This is accomplished by placing objects of known weight on the measuring ring and moving the dial until the measuring arm moves off the rest position. Numerous weights are used so a curve can be drawn. The scale readings are then related to dynes by the following equation:

$$\text{Force in dynes/scale unit} = \frac{(\text{object wt.})\ (980\ \text{cm. sec.}^2)}{\text{scale units}}$$

The sample is placed in a clean shallow dish and placed on the adjustable table of the tensiometer. The measuring ring must be absolutely clean as contamination will greatly affect the adhesion of the body measured. The best method to clean the ring is to heat it to redness over a Bunsen burner. The ring is then positioned so that the scale reads zero. The adjustable table is raised, positioning the ring in the fluid to the point that, if it were moved lower, there would be a transparent line formed just below the ring. The scale dial is carefully moved until the ring breaks free from the sample. A reading is taken and dynes per centimeter are calculated. The scale reading is entered into the following formula to obtain dynes per centimeter.

$$\text{Dynes/cm.} = \frac{(\text{scale units read})\ (\text{dynes/scale unit})}{\text{A constant based on the size of the ring}}$$

For the instrument and the ring used the constant was "8."

Before testing surface tension of rumen fluid, substances of known surface tension were tested. Two materials with widely different surface tensions are water at 18° C (73.05 d./cm.) and methanol at 20° C (22.6 d./cm.).

Samples of freshly cut alfalfa were obtained on the 3 days that rumen samples were taken. Proximate analysis was conducted on the accumulated samples for each week. The results are presented in Table 13. Care was taken in cutting alfalfa so there would be little variation in the maturity of the alfalfa consumed each week by the steers.

## Results and Discussion

### Grazing Trial

The feeding of grain on alfalfa pasture did not increase average daily gain. Steers grazing pasture without grain (molasses blocks available) had the largest gains (Table 4). Significant differences ($P < .05$) between treatments were found in 28-day and 56-day gains. However, differences between treatments had disappeared by the end of the trial. Refer to Table 8 for the analysis of variance.

The statistical analysis was designed to remove any influences of initial weight on rate of gain. The analysis, showing a significant regression coefficient of 1.10, indicated a direct relation between gain and beginning weight.

The equation used is:

$Y_{ijk} = u + T_i + b(x_j - \bar{x}j) + e_{ijk}$, where:

$Y_{ijk}$ = the $k^{th}$ steer with $j^{th}$ initial weight in the $i^{th}$ treatment

u = the overall mean common to all steers

$T_i$ = effect common to all steers in the $i^{th}$ treatment group

b = partial regression coefficients of the dependent variables on the independent continuous variables

$x_j$ = the continuous independent variable, initial weight, for the corresponding $Y_{ijk}$ observation

$\bar{x}$ = the arithmetic mean of the $x_j$'s

$e_{ijk}$ = effect of each individual steers, assumed to be distributed normally with a mean of zero and a variance of 2.

Table 4. SUMMARY OF STATISTICAL ANALYSIS ON FINAL WEIGHTS IN GRAZING TRIAL USING MULTIPLE COMPARISON

| Treatment Number | Description | 28-Day | 56-Day |
|---|---|---|---|
| 1 | Alfalfa pasture, 6-8 lb. milo, no Bloat Guard | 734.4 | 784.4 |
| 2 | Alfalfa pasture, 6-8 lb. milo, Bloat Guard | 719.7[b] | 762.7[b] |
| 3 | Alfalfa pasture, no grain, no poloxalene | 732.2 | 758.6[b] |
| 4 | Alfalfa pasture, no grain, poloxalene in blocks | 751.9 | 801.2 |
| 5 | Drylot, alfalfa hay, 6-8 lb. milo, no Bloat Guard | 722.9[a] | 773.5 |
| 6 | Drylot, alfalfa hay, 6-8 lb. milo, no Bloat Guard | 709.3[b] | 762.3[a] |

[a] Indicates significant difference from treatment 4 ($P < .05$).

[b] Indicates significant difference from treatment 4 ($P < .01$).

Highly significant differences ($P < .01$) for the first 28-day period were found between treatment 4 and treatments 2 or 6. There was also a significant difference between treatments 4 and 5 ($P < .05$).

A highly significant ($P < .01$) difference was found between treatment 4 and treatments 2 or 3 at 56 days. Significance was also observed

between treatment 4 and treatment 6 ($P < .05$).

The poor response of treatment 3 was probably due to a high incidence of bloat in some of the steers. Steers receiving grain on pasture gained less than those not receiving grain.

Differences among treatments were not significant when analyzed for the entire 84-day period. Gains in all groups decreased as the trial progressed, but gains were lowest in the latter portion of the trial for steers grazing pasture without grain. This might have indicated that pasture alone was not adequate to maintain good gains toward the end of the trial. Also, the grain may have had a beneficial effect on growth. The addition of grain did not increase gains in this trial; however, the results could have been different over an extended period.

Final weights were adjusted to remove the effect of initial weight (Table 5).

Table 5. ADJUSTED FINAL WEIGHTS

| | |
|---|---|
| Treatment 4 | 839.9 lb. |
| Treatment 1 | 820.4 lb. |
| Treatment 2 | 805.9 lb. |
| Treatment 5 | 798.0 lb. |
| Treatment 3 | 797.5 lb. |
| Treatment 6 | 786.9 lb. |

Neither treatment 1 nor 3 received bloat preventive while grazing alfalfa; however, gains were slightly higher for treatment 1. Steers in treatment 3 had a higher incidence of bloat which may explain this

difference. Bloat was less severe for treatment 1, probably because this group received grain and did not consume as much alfalfa.

Large variations in gain within treatments caused a large error term in the analysis of variance. Largest variations were in groups receiving grain, or when the incidence of bloating was greater (Table 9).

Individual variation among animals could have been due to differences in salt tolerance. Salt levels in the sorghum grain concentrate mixture ranged from 10% to 30%. The most common salt level was 20%. At these levels the steers were consuming between 0.6 and 1.8 lb. of salt daily.

Steers receiving sorghum grain consumed in excess of an average 6 lb. per head daily (Table 10). Bloat Guard was consumed at safe levels during the entire trial. The group receiving Bloat Guard in their grain consumed between 25 and 30 gm. daily. Twenty grams (10 gm. poloxalene) is recommended (Bartley et al., 1965). Bloat Guard contains 55% poloxalene by weight. Steers having access to a molasses block containing poloxalene consumed an average 0.49 lb. of the block daily. Since the block contains 30 gm. poloxalene per lb. the steers were consuming approximately 15 gm. of poloxalene daily, which is in excess of the 10 gm. minimum recommended level (Essig et al., 1965b). The blocks were fed in uncovered salt boxes and considerable rain caused some leaching loss.

Rate of gain appeared to be influenced by the incidence of bloat. This was supported by the large reduction in rate of gain for lot 2 (steers not receiving bloat preventive or grain) when the incidence and degree of bloat increased during the second 28-day period. Steer 292 gained 4.29 lb. daily during the first period and dropped to 1.07 lb.

daily for the second period (Table 7). Steer 291 dropped from 3.04 lb. daily to no gain. Both 292 and 291 had a high incidence of bloat during this period (Table 9). All of the steers in lot 2 had lower gains during the second period, but the two steers with a low incidence of bloat did not drop as abruptly. This indicates that animals do not gain as rapidly when experiencing bloat.

Bloat was successfully controlled by Bloat Guard in the grain ration or by poloxalene containing blocks (Table 9). Some bloat occurred in the steers receiving Bloat Guard and grain, but it appeared to be feedlot bloat rather than legume bloat. The incidence of bloat in this lot increased when steers received more grain and decreased when more salt was added to decrease grain consumption.

Good management was emphasized by Stiles et al. (1967), and supported by Foote et al. (1968), as essential for successful use of poloxalene containing molasses-salt blocks. This trial supports their conclusion.

One steer that was grazing alfalfa and had access to the poloxalene molasses block died near the end of the trial. This steer was posted on July 19, 1967. Necropsy finding suggested that frothy bloat was the cause of death. The suddenness of death was apparent, as the lot was checked between 4 and 5 p.m., and no bloat was observed. By 7:30 a.m. the following morning rigor mortis had set in. The steer that died had never bloated before during the trial and only one slight case of bloat (bloat scored 1⁻) had been observed in that lot.

In the death due to frothy bloat, management was probably a contributing factor. During periods of inclement weather the poloxalene-

molasses-salt blocks were allowed to get quite small before they were replaced. Blocks should have been placed in more than one location in each pasture to assure adequate consumption of poloxalene.

Rate of Removal Study

A Least Squares Analysis of Variance was calculated for the rumen fluid surface tension readings collected over the two three-week periods. The results from this analysis are shown in Tables 11 and 12.

Significant differences ($P < .01$) were found within treatments, feeding levels, and time of sampling. Differences due to sampling methods, replacing a broken surface tension ring, and trial number were non-significant.

The significant differences ($P < .01$) found between feeding levels of alfalfa do not follow a logical sequence. The highest surface tension should presumably occur with the highest feed consumption due to the dilution of the poloxalene. The highest surface tension occurred with highest feed consumption, but the lowest reading occurred at 40 lb. per day consumption. This could have been due to a difference in the alfalfa fed as it was necessary to move from field to field to have approximately the same maturity of alfalfa each week. Proximate analysis, conducted on combined samples for each week (Table 13), showed no indication of a feed quality difference that might explain the differences in surface tension. Proximate analysis gives no indication of levels of saponins or soluble proteins. These have a major influence on surface tension (Bartley et al., 1965; Grosskopf, 1964).

Twenty grams of poloxalene daily reduced surface tension signifi-

cantly ($P < .01$) more than 10 gm. daily; however, both levels were successful in controlling bloat. This trial indicated that 10 gm. will lower surface tension sufficiently to control bloat in steers weighing 750 to 800 lb. and consuming 50 lb. alfalfa. These same steers would probably consume larger amounts of alfalfa when grazing pasture than they did under trial conditions.

Time of sampling had the greatest effect on surface tension ($P < .001$). The lowest surface tension was at 10 a.m., followed by 7 p.m., and the highest was at 7 a.m. (Table 14). This would appear logical, since poloxalene was administered following the 7 a.m. sample.

Reddy et al. (1967) found that the effects of poloxalene were absent and surface tension returned to normal 48 hr. following administration. The results of this trial disagree with their finding as surface tension had not returned to normal after four days.

## Summary and Conclusion

Thirty-eight 600 lb. steers were used to study the problems involved when grazing steers on alfalfa with and without supplemental grain using Bloat Guard and poloxalene to control bloat. The research also involved a comparison of the rate of gain of steers fed rolled sorghum grain on alfalfa pasture to that of steers fed the same grain ration and free choice alfalfa hay in drylot. A comparison of the effectiveness of Bloat Guard in the grain ration and poloxalene in molasses-salt blocks was conducted.

Three groups of four steers each, grazed alfalfa without grain; they were allowed one-half acre per head. One group received no bloat-

controlling agent, while the other two received poloxalene in a molasses-salt block. Three groups of six steers each grazed one third acre per head, while receiving 6 to 8 lb. of sorghum grain daily. Two of these groups received Bloat Guard in the grain and the third group, serving as a control, received no bloat preventive. Two groups of four steers each were fed alfalfa hay free-choice and 6 to 8 lb. sorghum grain daily in drylot. One lot received Bloat Guard and the other received no bloat preventive. Grain was fed in self feeders and consumption limited with salt.

All groups were weighed at 28-day intervals for three consecutive periods. Bloat scores (one to five, with one being the least severe) were taken twice daily.

Differences in weight gain due to treatment for the entire 84-day trial were not statistically different. However, differences were significant during the first part of the test. At 28 days the steers grazing alfalfa pasture, having access to a molasses-salt block containing poloxalene, had gained more ($P < .05$) than steers in drylot and steers receiving Bloat Guard and grain on pasture. At 56 days steers grazing alfalfa and having access to the molasses-salt block containing poloxalene had gained significantly more than the steers in drylot, steers receiving grain and Bloat Guard on pasture and the steers grazing alfalfa without a preventive.

Bloat was successfully controlled when the steers received Bloat Guard in the grain or had access to a poloxalene containing molasses-salt block. There appeared to be a decrease in gain with an increase in bloat incidence. One steer died during the trial, probably

due to management not replacing the molasses-salt blocks often enough during one period. This points to the necessity of an adequate supply at all times.

Two sets of rumen-fistulated, identical twin steers were used to study the level of poloxalene required to control surface tension when varying levels of alfalfa were consumed. The rate of removal of poloxalene was studied by feeding 20, 40, and 50 lb. of alfalfa using two levels of poloxalene (10 and 20 gm.) for each level of alfalfa. Alfalfa was fed as fresh green chop.

Surface tension was determined on a rumen fluid sample to indicate fluctuations in poloxalene levels.

Significant differences were found within treatments, feeding levels, and the time of sampling.

The lowest concentration of poloxalene was found when 50 lb. of alfalfa was fed. However, the highest concentration was observed when 40 lb. was fed ($P < .01$).

Twenty grams of poloxalene per day lowered surface tension more than 10 gm. ($P < .01$). Both levels successfully controlled bloat.

Differences in surface tension with time were highly significant ($P < .001$). Surface tension readings were lowest at 10 a.m., followed by 7 p.m. and 7 a.m. This trend was expected, since poloxalene was administered following the 7 a.m. sampling period. The surface tension readings indicated that there is little danger of bloat when poloxalene is administered daily.

Surface tension data collected in this trial showed that poloxalene is not completely removed from the rumen for at least 4 days.

Ten grams of poloxalene administered daily successfully controlled bloat in 750-800 lb. fistulated steers, consuming up to 50 lb. of fresh green chop daily.

# APPENDIX

Table 6. TREATMENT SUMMARY FOR GRAZING TRIAL

| Lot Number | Pasture | Sorghum Grain | Bloat Guard | Molasses Block (Pol.) |
|---|---|---|---|---|
| 1 | yes | yes | no | no |
| 2 | yes | no | no | no |
| 3 | yes | no | no | yes |
| 4 | yes | no | no | yes |
| 5 | yes | yes | yes | no |
| 6 | yes | yes | yes | no |
| 7 | no | yes | no | no |
| 8 | no | yes | yes | no |

Table 7. AVERAGE DAILY GAIN FOR STEERS ON GRAZING TRIAL

| Steer Number | First 28 Days | Second 28 Days | Third 28 Days | Total ADG |
|---|---|---|---|---|
| | | LOT 1 | | |
| 294 | 3.03 | 1.96 | .54 | 1.85 |
| 295 | 3.21 | 1.42 | 1.43 | 2.02 |
| 296 | 3.39 | 1.60 | 1.61 | 2.20 |
| 297 | 3.39 | 1.96 | 1.43 | 2.26 |
| 298 | 3.21 | 2.14 | 1.25 | 2.20 |
| 293 | 1.96 | 1.96 | .89 | 1.61 |
| Avg. | 3.03 | 1.84 | 1.19 | 2.02 |
| | | LOT 2 | | |
| 290 | 2.14 | .89 | 1.43 | 1.49 |
| 291 | 3.04 | .00 | 1.07 | 1.37 |
| 292 | 4.29 | 1.07 | 1.07 | 2.14 |
| 289 | 2.50 | 1.96 | 1.79 | 2.08 |
| Avg. | 2.99 | .98 | 1.34 | 1.77 |
| | | LOT 3 | | |
| 286 | 3.04 | 2.14 | 1.07 | 2.08 |
| 287 | 2.86 | 2.86 | 1.43 | 2.38 |
| 288 | 3.93 | 1.61 | 1.07 | 2.20 |
| 285 | 4.64 | 1.79 | 1.61 | 2.69 |
| Avg. | 3.62 | 2.10 | 1.29 | 2.34 |
| | | LOT 4 | | |
| 268 | 3.04 | 1.79 | 1.43 | 2.08 |
| 269 | 3.57 | .54 | 1.07 | 1.73 |
| 270 | 5.00 | 1.96 | 1.43 | 2.80 |
| 267[1] | 3.39 | 1.79 | 1.43 | 2.20 |
| Avg. | 3.75 | 1.52 | 1.34 | 2.20 |
| | | LOT 5 | | |
| 272 | 3.39 | 1.07 | 1.25 | 1.90 |
| 273 | 3.92 | .53 | -.36 | 1.43 |
| 274 | 2.67 | .89 | 2.32 | 1.96 |
| 283 | 2.32 | 1.25 | 1.43 | 1.67 |
| 284 | 2.14 | 1.07 | 2.50 | 1.90 |
| 271 | 2.50 | 1.25 | 2.14 | 1.96 |
| Avg. | 2.65 | 1.01 | 1.55 | 1.81 |

Table 7. AVERAGE DAILY GAIN FOR STEERS ON GRAZING TRIAL (Con't)

| Steer Number | First 28 Days | Second 28 Days | Third 28 Days | Total ADG |
|---|---|---|---|---|
| | | LOT 6 | | |
| 261 | 2.68 | 1.96 | 3.57 | 2.74 |
| 262 | 2.50 | 2.86 | .36 | 1.90 |
| 263 | 3.21 | 1.79 | 3.03 | 2.68 |
| 264 | 2.50 | 2.14 | -.54 | 1.37 |
| 265 | 2.86 | 1.07 | 1.43 | 1.79 |
| 260 | .36 | 3.57 | .36 | 1.43 |
| Avg. | 2.35 | 2.23 | 1.37 | 1.98 |
| | | LOT 7 | | |
| 280 | 3.39 | 1.96 | 1.79 | 2.38 |
| 281 | 2.14 | 2.32 | .18 | 1.55 |
| 282 | 3.57 | 1.96 | .18 | 1.90 |
| 279 | 2.32 | .54 | 1.96 | 1.61 |
| Avg. | 2.86 | 1.70 | 1.03 | 1.86 |
| | | LOT 8 | | |
| 276 | 1.79 | 1.07 | .89 | 1.25 |
| 277 | 2.14 | 2.86 | .00 | 1.67 |
| 278 | 3.04 | 1.07 | 3.21 | 2.44 |
| 275 | 2.50 | 2.14 | .00 | 1.55 |
| Avg. | 2.37 | 1.79 | 1.03 | 1.73 |

[1] Died.

Table 8. ANALYSIS OF VARIANCE FOR GRAZING TRIAL

Twenty-eight Day Weights

| Source | Deviation Sum of Squares | Degrees of freedom | Mean Square |
|---|---|---|---|
| Treatment | --- | --- | --- |
| Error | 13873 | 31 | 447.5 |
| Total | 20940 | 36 | --- |
| Difference for testing adjusted treatment | 7067 | 5 | 1413.4 |
| | | | F = 3.15* |

Fifty-six Day Weights

| Source | Deviation Sum of Squares | Degrees of freedom | Mean Square |
|---|---|---|---|
| Treatment | --- | --- | --- |
| Error | 18054 | 31 | 582.3 |
| Total | 26857 | 36 | --- |
| Difference for testing adjusted treatment | 8803 | 5 | 1760.6 |
| | | | F = 3.02* |

Eighty-four Day Weights

| Source | Deviation Sum of Squares | Degrees of freedom | Mean Square |
|---|---|---|---|
| Treatment | --- | --- | --- |
| Error | 34160 | 31 | 1005.2 |
| Total | 43654 | 36 | --- |
| Difference for testing adjusted treatment | 9494 | 5 | 1898.8 |
| | | | F = 1.88* |

*P < .05

Table 9. EFFECTIVENESS OF POLOXALENE FOR CONTROLLING BLOAT IN STEERS GRAZING IMMATURE ALFALFA

| Steer Number | Lot Number | Bloat Index[1] | Incidence of Bloat | Max. Bloat | Avg. Score[2] |
|---|---|---|---|---|---|
| 294 | 1 | 60 | 3 | 1⁻ | 1⁻ |
| 295 | 1 | 1468 | 38 | 2 | 1 |
| 296 | 1 | 5575 | 90 | 3 | 1+ |
| 297 | 1 | 4067 | 34 | 3+ | 2+ |
| 298 | 1 | 1409 | 42 | 2 | 1 |
| 293 | 1 | 139 | 5 | 1 | 1⁻ |
| 290 | 2 | 2401 | 59 | 2+ | 1 |
| 291 | 2 | 7917 | 102 | 3+ | 2⁻ |
| 292 | 2 | 12282 | 128 | 4 | 2 |
| 289 | 2 | 6528 | 122 | 3+ | 1+ |
| 286 | 3 | 0 | 0 | 0 | 0 |
| 287 | 3 | 0 | 0 | 0 | 0 |
| 288 | 3 | 40 | 1 | 1 | 1 |
| 285 | 3 | 40 | 1 | 1 | 1 |
| 268 | 4 | 0 | 0 | 0 | 0 |
| 269 | 4 | 0 | 0 | 0 | 0 |
| 270 | 4 | 20 | 1 | 1⁻ | 1⁻ |
| 267 | 4 | 99 | 1 | 5 | 5 |
| 272 | 5 | 20 | 1 | 1⁻ | 1⁻ |
| 273 | 5 | 20 | 1 | 1⁻ | 1⁻ |
| 274 | 5 | 20 | 1 | 1⁻ | 1⁻ |
| 283 | 5 | 99 | 3 | 1 | 1 |
| 284 | 5 | 714 | 14 | 2+ | 1+ |
| 271 | 5 | 60 | 1 | 1+ | 1+ |
| 261 | 6 | 0 | 0 | 0 | 0 |
| 262 | 6 | 0 | 0 | 0 | 0 |
| 263 | 6 | 0 | 0 | 0 | 0 |
| 264 | 6 | 139 | 4 | 1 | 1 |
| 265 | 6 | 0 | 0 | 0 | 0 |
| 260 | 6 | 40 | 1 | 1 | 1 |

[1]Total of all bloat scores divided by the number of times checked times 10,000.

[2]Degree of bloat scored from 0 (no bloat) to 5 (death). Refer to Table 2.

Table 10. AVERAGE DAILY CONSUMPTION OF FEEDS FOR STEERS ON GRAZING TRIAL

| Lot No. | Mol. Block[a] | Sorghum Grain[a] | Salt[a] | Bloat Guard[b] |
|---|---|---|---|---|
| 1 | .15 | 6.23 | 1.45 | NA |
| 2 | .79 | NA[1] | NA | NA |
| 3 | .49 | NA | NA | NA |
| 4 | .49 | NA | NA | NA |
| 5 | .40 | 5.50 | 1.17 | 23.10 |
| 6 | .40 | 6.33 | 1.47 | 26.71 |
| 7 | .41 | 6.93 | 1.65 | NA |
| 8 | .23 | 6.50 | 1.52 | 30.04 |

[a]Pounds per day.

[b]Grams per day.

[1]NA - steers did not receive grain.

Table 11. LEAST SQUARE ANALYSIS OF VARIANCE ON SURFACE TENSION READINGS

| | |
|---|---|
| Mean Value for Surface Tension | 43.004527 |
| Deviations from the Mean | |
| Alfalfa level** | |
| 20% alfalfa | 0.147751 ± 0.230576[a] |
| 40% alfalfa | -0.750427 ± 0.2042939 |
| 50% alfalfa | 0.602676 ± 0.229092 |
| Poloxalene dosage** | |
| 10 gm. | 0.368140 ± 0.1362483 |
| 20 gm. | -0.368140 ± 0.1362483 |
| Hour of sampling*** | |
| 7 a.m. | 1.460901 ± 0.19341119[b] |
| 10 a.m. | -1.197712 ± 0.19341119 |
| 7 p.m. | -0.263189 ± 0.195575 |
| Trial | |
| Initial | -0.277215 ± 0.2840943 |
| Replication | +0.277215 ± 0.2840943 |
| Ring[1] | |
| Original | 0.164865 ± 0.277979 |
| Replacement | -0.164865 ± 0.277979 |
| Sampling method | |
| Sampling tube | -0.042224 ± 0.2392791 |
| Whole contents | 0.042224 ± 0.2392791 |
| Interaction between treatment and feed level non-significant | |

**P < .01
***P < .001

[1]New surface tension ring, new tension wire and new correlation constant.

[a]P < .01 significance shown between levels 20% and 40%, and 40% and 50%. No significance between 20% and 50% level.

[b]P < .001 between each time.

Table 12. LEAST SQUARES ANALYSIS OF VARIANCE ON SURFACE TENSION READINGS

| Analysis of Variance Table | | | |
|---|---|---|---|
| Source of Variance | Degrees of Freedom | Mean Square | F |
| Level of alfalfa** | 2 | 29.6228 | 7.40 |
| Poloxalene dosage*** | 1 | 29.2561 | 7.31 |
| Time of sampling*** | 2 | 130.8570 | 32.64 |
| Trial replication | 1 | 3.8174 | .95 |
| Rings | 1 | 1.4099 | .35 |
| Method of sampling | 1 | 0.1249 | .03 |
| Feed X treatment | 2 | 4.7086 | 1.17 |
| Error | 205 | 4.0094 | |
| Total | 215 | | |

**P $<$ .01

***P $<$ .001

Table 13. PROXIMATE ANALYSIS OF ALFALFA SAMPLES

| Week | Water | Ether Extract | Crude Protein | Crude Fiber | NFE | Ash |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | % |
| 1 | 74.9 | .54 | 5.08 | 7.54 | 10.01 | 1.93 |
| 2 | 77.6 | .48 | 4.85 | 5.82 | 9.83 | 1.75 |
| 3 | 83.6 | .41 | 4.43 | 3.91 | 6.45 | 1.80 |
| 4 | 80.6 | .47 | 4.53 | 4.86 | 7.97 | 1.57 |
| 5 | 74.6 | .54 | 4.82 | 7.70 | 10.54 | 1.80 |
| 6 | 72.1 | .57 | 5.14 | 8.27 | 11.70 | 2.22 |

Table 14. SURFACE TENSION (DYNES) FOR RATE OF REMOVAL TRIAL

| | Trial 1 | | | |
|---|---|---|---|---|
| | Steer 3 (10 gm)[1] | Steer 4 (20 gm)[1] | Steer 5 (10 gm)[1] | Steer 6 (20 gm)[1] |
| | Week 1 (20 lbs. alfafla fed daily) | | | |
| Day 1 | | | | |
| 7 a.m. | 50.19 | 51.76 | 48.62 | 51.43 |
| 10 a.m. | 36.69 | 39.08 | 40.16 | 37.87 |
| 7 p.m. | 43.64 | 44.25 | 45.37 | 44.44 |
| Day 2 | | | | |
| 7 a.m. | 45.93 | 44.36 | 45.76 | 44.36 |
| 10 a.m. | 38.99 | 40.33 | 40.66 | 39.95 |
| 7 p.m. | 45.24 | 42.80 | 44.14 | 40.28 |
| Day 3 | | | | |
| 7 a.m. | 44.59 | 43.24 | 44.02 | 43.69 |
| 10 a.m. | 38.43 | 40.95 | 39.61 | 39.54 |
| 7 p.m. | 43.24 | 41.62 | 44.48 | 43.36 |
| | Week 2 (40 lbs. alfalfa fed daily) | | | |
| Day 1 | | | | |
| 7 a.m. | 48.07 | 47.39 | 48.45 | 46.33 |
| 10 a.m. | 39.44 | 35.68[2] | 39.88 | 40.33 |
| 7 p.m. | 42.52 | 43.75 | 42.99 | 41.50 |
| Day 2 | | | | |
| 7 a.m. | 42.12 | 42.35 | 44.64 | 41.45 |
| 10 a.m. | 43.30 | 37.97 | 37.41 | 35.81 |
| 7 p.m. | 42.09 | 43.72 | 41.95 | 41.80 |
| Day 3 | | | | |
| 7 a.m. | 42.09 | 44.00 | 41.95 | 40.91 |
| 10 a.m. | 40.08 | 36.04[3] | 41.21 | 37.50 |
| 7 p.m. | 40.91 | 39.44 | 41.36 | 40.01 |
| | Week 3 (50 lbs. alfalfa fed daily) | | | |
| Day 1 | | | | |
| 7 a.m. | 45.80 | 47.55 | 47.40 | 46.36 |
| 10 a.m. | 37.81 | 43.13 | 43.72 | 43.13 |
| 7 p.m. | 42.23 | 42.23 | 43.72 | 42.99 |
| Day 2 | | | | |
| 7 a.m. | 42.23 | 44.17 | 45.04 | 44.76 |
| 10 a.m. | 43.72 | 42.82 | 42.54 | 42.39 |
| 7 p.m. | 43.31 | 42.99 | 43.31 | 43.72 |
| Day 3 | | | | |
| 7 a.m. | 43.58 | 44.17 | 45.18 | 44.31 |
| 10 a.m. | 41.50 | 43.72 | 41.21 | 43.27 |
| 7 p.m. | 44.00 | 43.58 | 44.59 | 42.84 |

Table 14. SURFACE TENSION (DYNES) FOR RATE OF REMOVAL TRIAL (Con't)

| | Trial 2 | | | |
|---|---|---|---|---|
| | Steer 3 (20 gm)[1] | Steer 4 (10 gm)[1] | Steer 5 (20 gm)[1] | Steer 6 (10 gm)[1] |
| | Week 1 (20 lbs. alfalfa fed daily) | | | |
| Day 1 | | | | |
| 7 a.m. | 43.58 | 45.35 | 45.49 | 44.90 |
| 10 a.m. | 41.50 | 43.58 | 40.91 | 45.35 |
| 7 p.m. | 42.82 | 44.00 | 41.64 | 44.17 |
| Day 2 | | | | |
| 7 a.m. | 43.58 | 44.31 | 43.27 | 46.22 |
| 10 a.m. | 42.99 | 43.72 | 43.13 | 44.31 |
| 7 p.m. | 41.50 | 42.54 | 42.54 | 43.13 |
| Day 3 | | | | |
| 7 a.m. | 41.64 | 42.54 | 42.54 | 43.31 |
| 10 a.m. | 41.36 | 42.09 | 40.46 | 42.99 |
| 7 p.m. | 42.23 | 43.13 | 42.99 | 43.72 |
| | Week 2 (40 lbs. alfalfa fed daily) | | | |
| Day 1 | | | | |
| 7 a.m. | 42.54 | 42.23 | 43.31 | 44.31 |
| 10 a.m. | 42.54 | 42.23 | 41.95 | 43.58 |
| 7 p.m. | 41.50 | 42.39 | 42.68 | 43.58 |
| Day 2 | | | | |
| 7 a.m. | 43.13 | 42.99 | 43.27 | 43.58 |
| 10 a.m. | 43.58 | 42.54 | 41.80 | 45.04 |
| 7 p.m. | 41.95 | 42.09 | 42.99 | 43.13 |
| Day 3 | | | | |
| 7 a.m. | 42.82 | 44.31 | 43.13 | 43.27 |
| 10 a.m. | 43.31 | 44.76 | 44.45 | 44.76 |
| 7 p.m. | 39.27 | 39.58 | 39.27 | 42.54 |
| | Week 3 (50 lbs. alfalfa fed daily) | | | |
| Day 1 | | | | |
| 7 a.m. | 44.31 | 44.59 | 44.76 | 44.59 |
| 10 a.m. | 45.94 | 47.26 | 44.76 | 44.90 |
| 7 p.m. | 43.72 | 45.72 | 41.95 | 44.17 |
| Day 2 | | | | |
| 7 a.m. | 43.13 | 43.72 | 42.09 | 42.54 |
| 10 a.m. | 41.50 | 44.00 | 42.99 | 43.86 |
| 7 p.m. | 41.05 | 43.31 | 32.09 | 42.68 |
| Day 3 | | | | |
| 7 a.m. | 41.36 | 44.90 | 41.50 | 44.00 |
| 10 a.m. | 42.23 | 43.13 | 41.80 | 42.99 |
| 7 p.m. | 41.64 | 42.82 | 41.95 | 42.54 |

[1]Grams of poloxalene administered daily.

[2]Steer got out of pen and was bloated prior to administration of poloxalene and seemed to lack the rumen motility needed to mix the poloxalene.

[3]Steer got out of pen and ate large quantities of straw and hay.

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# POLOXALENE FOR ALFALFA BLOAT PREVENTION IN BEEF STEERS--FEEDING METHODS, GROWTH EFFECTS, AND RATE OF DRUG REMOVAL FROM THE RUMEN

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The development of poloxalene has opened the possibility of using alfalfa for large scale grazing of beef cattle.

This project was designed to study the problems involved when grazing steers with and without grain on alfalfa pasture. The research involved: (1) a comparison of the rate of gain of steers fed sorghum grain on alfalfa pasture with the gain of drylot steers fed the same grain ration and alfalfa hay; (2) a comparison of the effectiveness of Bloat Guard (poloxalene) in the grain ration and poloxalene in molasses-salt blocks; and (3) a study of the rate of removal of poloxalene from the rumen of beef steers fed lush alfalfa at different levels of consumption.

No statistically significant differences were noted for the entire period in rate of gain. However, for the 28- and 56-day portion of the trial, steers grazing alfalfa, having access to only a molasses-salt block containing poloxalene, gained significantly faster than either the drylot steers or the steers receiving grain on pasture.

Bloat was successfully controlled by both Bloat Guard in the grain ration and the poloxalene-containing molasses-salt block.

In the rate of removal study, surface tension was determined on the rumen fluid sample to estimate fluctuation in poloxalene level. Significant differences were found within treatments ($P < .01$), feeding levels ($P < .01$), and time of sampling ($P < .001$).

The lowest rumen fluid surface tension was found when feeding 50 lb. of green alfalfa, and the highest at the 40 lb. level ($P < .01$).

Surface tension was highest just before poloxalene administration, dropped at the time of administration and returned to the pre-

administration level ($P < .001$).

Twenty grams of poloxalene reduced the surface tension more ($P < .01$) than 10 gm.; however the lower level successfully controlled bloat in 750-800 lb. fistulated steers, consuming up to 50 lb. of fresh green chop daily.